A SPHYGMOGRAPH FOR CONTINUOUS TRACINGS.

By J. C. VAUGHAN, M.B.,
House-Physician to the Bradford Infirmary, Yorkshire.

Some time ago, while resident physician to Professor T. R. Fraser's wards in the Royal Infirmary, Edinburgh, my attention was directed in a special way to the examination of the pulse. Marey's sphygmograph was the instrument used, and many cases of mitral disease with very irregular cardiac action came under observation. In these cases it was the practice to obtain at one sitting a series of tracings showing all the variations of rhythm presented by the pulse. Ever since, in observing similar cases, I have followed the same plan, and in the hospital here I have, by the courtesy of the honorary medical staff, had abundant opportunity of comparing the results yielded by short tracings with those given by continuous tracings as regards their respective value as clinical records.

Working with Marey's or Dudgeon's instrument, one has sometimes to wait long before the tracings obtained fairly represent the modes of irregularity shown by the heart, and it not infrequently happens that tracings taken within half a minute of each other (*vide* Figs. 1 and 2) show characters so widely different that it would be exceedingly difficult to recognise them as representations of cardiac rhythm so nearly related in point of time. The time and trouble required to obtain a fairly representative series of tracings is often considerable; while, at the same time, the method of procedure and the conclusions drawn as to the character and degree of irregularity are necessarily to a certain extent arbitrary and indefinite, and seem to be open to the objection that the sphygmographic records are in themselves short, incomplete, and disconnected. And, if this may be said of a series of disconnected tracings, it seems fair to say that, in cases of irregular heart action, no single tracing of any such series can be held to represent with any definite degree of accuracy and completeness the character of the heart's action at the time. But if the tracings were not disconnected their joint value as a continuous tracing would be much greater.

Considering the matter from this point of view, it seemed to me that, if sphygmography be of value, it would be well if we had some convenient method by which we could obtain a continuous tracing extending over several minutes, and showing at a glance the characters of several hundred pulse waves, and of all the phases of abnormality or irregularity present, and the dominant as well as the intercurrent variations of cardiac rhythm—showing these in their true time relations to each other, and giving a fair representation of the *average* character of the work done by the heart. And surely a method of sphygmography would, for purposes of clinical study and demonstration, be preferable which would enable us thus to measure more accurately the conditions with which we deal, and which would give us as results not the gleanings from observations of a few seconds' duration—recording only a few pulse-beats—a period during which an irregular heart may be found at its best or at its worst, but a good representation of the *average* quality of the heart's work.

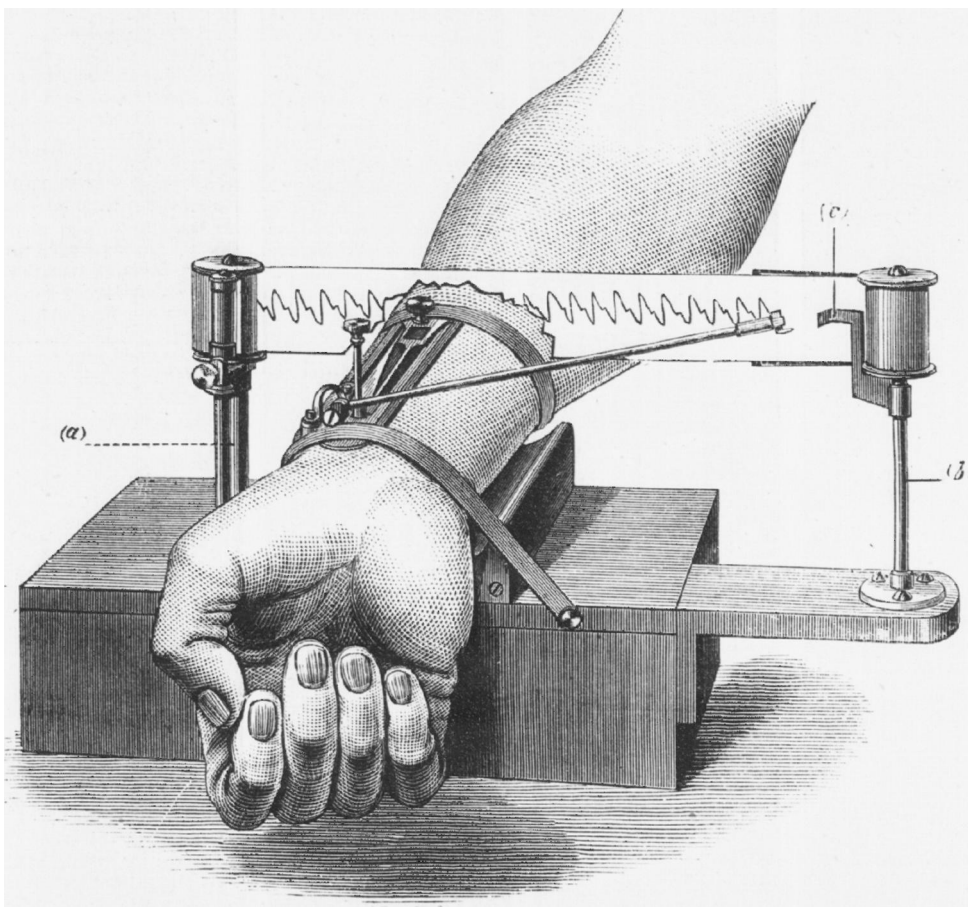


Fig. 3.—Sphymograph applied for Continuous Tracing.

Some such average may, of course, be obtained by multiplying tracings taken with Marey's or Dudgeon's instrument; but it seemed to me that a continuous tracing offered clearer results and a fuller and wider view of conditions under observation than any to be obtained by tying together in a more or less arbitrary way observations consisting of detached parts in separate short tracings. Accordingly, thinking that a sphygmograph answering the purpose in view may prove useful, I devised the instrument figured, and it was made for me by Mr. Alexander Fraser, of 7, Lothian Street, Edinburgh. It consists of the following parts:—

1. A frame carrying a recording lever, and constructed somewhat on the same principle as Marey's instrument. The lever moves at right-angles to the long axis of the frame; at its free end it carries a glass cup having a capillary writing-point, and containing ink. Over the attached end of the lever is a small spring, which does not touch the lever except the latter is thrown up very powerfully, when it checks any excessive range of movement.

2. A sliding hand-rest, fitting on to the box containing the driving machinery, and allowing the hand to be put into any suitable position.

3. The paper-carrying apparatus, consisting of (1) an upright (*a*) carrying two milled cylinders, which, on being rotated, draw a ribbon of tracing paper off a reel placed on a second upright (*b*), and past the writing point. Standing out from (*b*) is a brass plate (almost hidden in the illustration), over which the paper is drawn, a tension spring (*c*) keeping the paper flat and sufficiently taut to allow an even writing surface for the pen, which writes against the brass plate. The reel will hold a ribbon of paper long enough to last for several minutes, and a trigger starts and stops the driving machinery. The two uprights and the bracket on which *b* stands can be taken off at will, so that the instrument could be readily put into a small compass, and, when packed, could

Fig. 4.—Continuous tracing (one-third full length) from case of extreme mitral lesion.

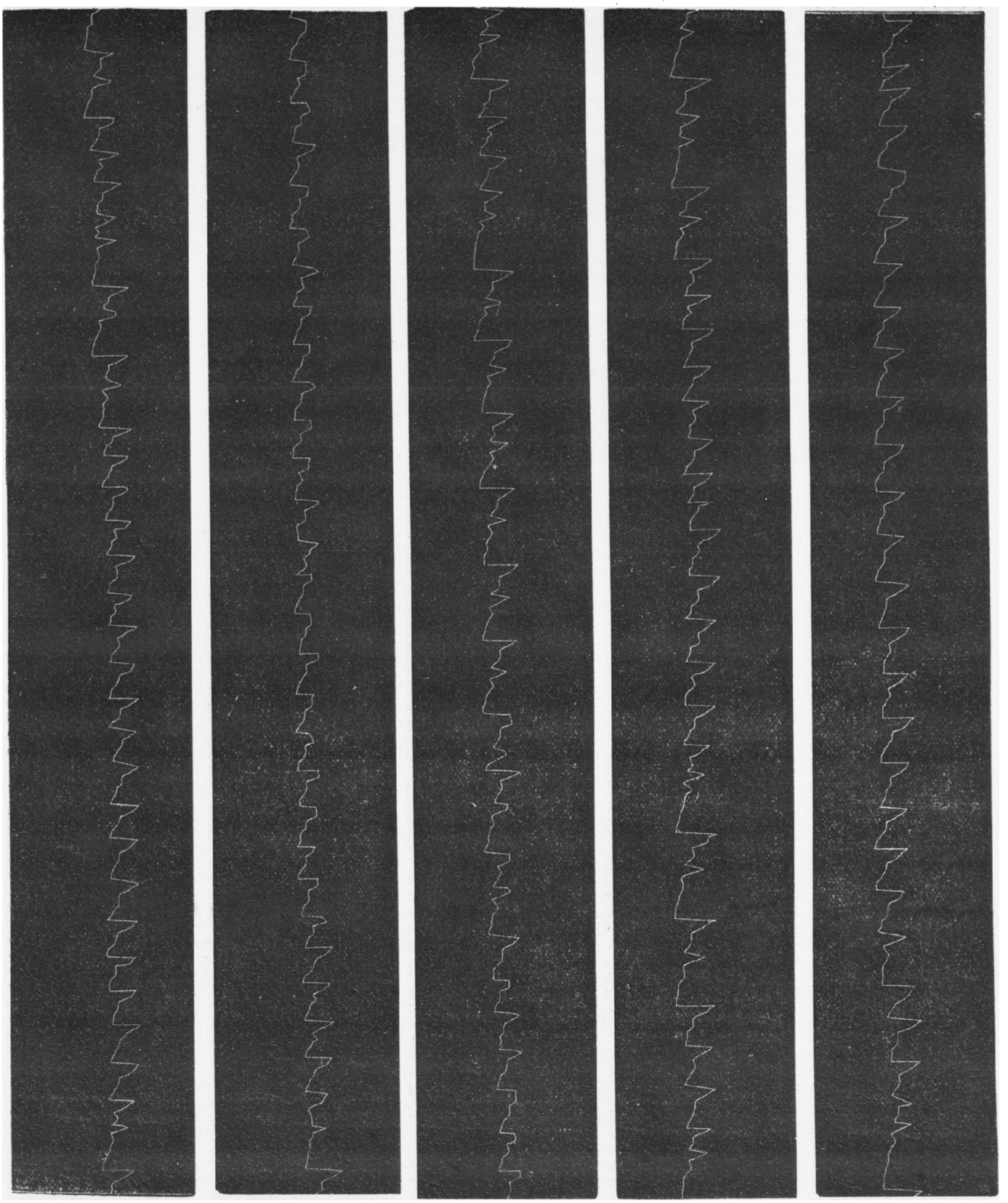
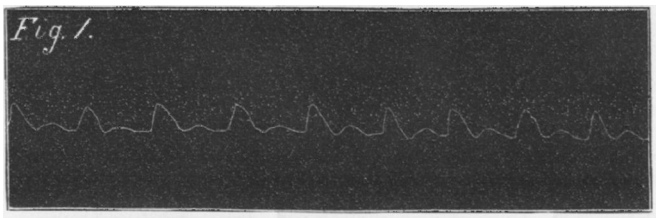
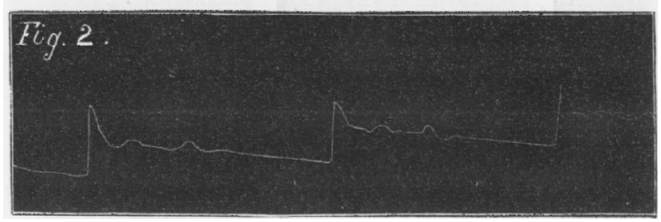


Fig. 5.—Continuous tracing (one-fifth full length) from a case of fatty heart in an asthmatic patient showing pulse-waves over exactly two minutes.

be very conveniently carried. The necessity for smoking and varnishing paper is done away with by the use of ink, and the tracings show that the friction between the writing point and the paper is scarcely more than in other sphygmographs; and, as regards their merits as sphygmograms, the tracings speak for themselves.[1]

The instrument was devised in October, 1886, and made in December of the same year. Since then repeated trials, permitted by the courtesy of the honorary medical staff and made in the





Figs. 1 and 2.—Tracings with Marey's instrument from same artery within half a minute of each other without moving the sphygmograph.

hospital here, have brought me to the belief that it may prove useful, more especially for purposes of observation, and for demonstration of the pulse phenomena of heart disease.

In conclusion I must express my obligations to Professor Fraser for his kindly encouragement, to Dr. G. L. Gulland for the drawing, and to Mr. Alexander Fraser, of Lothian Street, for many valuable suggestions, and for the successful carrying out of the mechanical part of the work.

THE DISTRIBUTION OF PARALYSIS AND ANÆSTHESIA IN INJURIES OF THE CERVICAL REGION OF THE SPINAL CORD.[2]

By WILLIAM THORBURN, F.R.C.S.Eng.,
Surgical Registrar, Manchester Royal Infirmary, etc.

Gentlemen—Having been thrown by circumstances into connection with a large number of legal investigations relating to railway accidents, and having hence been led to take a special interest in spinal injuries, I have been much impressed by the vagueness of the usually received accounts of these affections, and have endeavoured to ascertain more accurately than is commonly done the reason and the import of some of the more complex collections of symptoms which they present to us. In order to obtain reliable data, I have carefully observed a large number of serious cases which have come under my observation as Surgical Registrar in the Manchester Royal Infirmary, the staff of which hospital has kindly allowed me to use the cases which have there presented themselves. Among others, I have now watched nineteen cases of injury in the region of the cord from which arise the nerves of the brachial plexus, and I have been led to certain results which appear to me to possess both a purely scientific and a medico-legal interest.

To-day I propose to bring before you some of these results, and, in doing so, may say that the cases which I have now briefly to bring under your notice will be found reported *in extenso* in a paper which I published in *Brain* in January, 1887, and in a second communication in the same journal.

The only two points in which I shall endeavour to-day to interest you are the distribution of the paralysis and of the anæsthesia observed in injuries at various levels of the brachial enlargement of the cord—that is, from the fourth cervical to the first dorsal vertebra.

First, then, as regards the paralysis, I find that with a little care it is possible to ascertain very accurately—much more accurately than is usually done—the exact extent of the paralysis produced in crushes of the cord at different levels, and also to trace the course of the ascending myelitis which frequently ensues upon such injuries by observing the way in which the muscles of the upper limb become subsequently paralysed. Such an examination has led me to assign a definite order to the spinal nuclei, if I may so call them, of the brachial enlargement—an arrangement which I have tabulated in the following manner:

Arrangement of the Muscular Nuclei of the Brachial Enlargement of the Spinal Cord.

Supra-spinatus and infra-spinatus Teres minor (?)	4th cervical nerve.
Biceps Brachialis anticus Deltoid Supinator longus Supinator brevis (?)	5th cervical nerve.
Subscapularis Pronators Teres major Latissimus dorsi Pectoralis major Triceps Serratus magnus	6th cervical nerve.
Extensors of the wrist	7th cervical nerve.
Flexors of the wrist	8th cervical nerve.
Interossei Other intrinsic muscles of the hand	1st dorsal nerve.

That there are certain gaps and probably some inaccuracies in this table I cannot doubt, but that in the main it will be found to hold good I am the more convinced by the fact that the results obtained tally closely with observations on the anatomy and physiology of the cord made in various other ways. Several of the muscles referred to—notably the pectoralis major—are certainly supplied from more than one level of the cord, but the nature of my inquiry permits only of recognising the chief of these levels—that is, the one from which are derived the nerve fibres supplying the functionally most powerful part of the muscle. I would further point out that, as I shall shortly explain more fully, the limbs of patients affected by the various combinations of partial paralysis acquire certain characteristic positions, so much so, that in one or two of the better marked instances it has been possible to diagnose the exact seat of the lesion by a mere glance at the attitude of the patient's limb. Time will allow of my mentioning only a few of the cases on which my conclusions are based, but these few will serve to indicate the nature of the evidence.

Commencing then at the upper part of the region to which we have referred, I have had two cases in which there was found at the *post-mortem* examination a fracture-dislocation between the fourth and fifth cervical vertebræ, with a complete crush of the cord above the level of the fifth cervical nerve roots. In both of these cases the upper limbs appeared to be completely paralysed as regards both their extrinsic and intrinsic muscles. In one of them the levator anguli scapulæ and trapezius were found not to be paralysed, the former distinctly contracting when the patient took a deep breath, but both of these muscles are undoubtedly innervated from above the brachial enlargement. Unfortunately, these were among my earlier cases, and the condition of the supra- and infra-spinati muscles was not noted, but from reasons which I shall shortly give I can assign both of these muscles to the fourth cervical nerve root, and the teres minor probably accompanies them.

Passing downwards I come next to a remarkable and most instructive group of cases, most typically represented by a man who survived for twenty-six days a fracture-dislocation of the fifth cervical vertebra. Unlike the majority of these dislocations the upper vertebra—the fifth—was displaced backward, and in such a manner that the fifth cervical nerve roots, which, it will be remembered, arise above that vertebra, were uninjured, and the cord was crushed below these roots. Now, on admission, and for a considerable period thereafter, this man did not present complete paralysis of the upper limbs. The trunk and lower extremities were affected as usual in such injuries, but the arms

[1] The tracings sent are only one-third of their original length. The drawing is that of the instrument as first used. A neater model can easily be produced.

[2] Read in the Section of Surgery, at the Annual Meeting of the British Medical Association, held in Glasgow, August, 1888.